

VIII. SFOF Development

DEVELOPMENT AND IMPLEMENTATION

A. SFOF Digital Television Assembly, F. L. Singleton

1. Introduction

The digital television assembly (DTV) is a part of the user terminal and display subsystem in the SFOF. The purpose of the DTV is to provide the SFOF with a flexible real-time and near-real-time data display system. This display system will provide a multichannel, computer-generated display of alphanumeric and graphic information to support the various space flight missions starting with *Mariner* Mars 1971. The displayed information will be used for data analysis, decision making, monitoring, and management information.

The DTV will provide 60 channels of digital television displays with both alphanumeric and graphic display capability. These displays will be shown on various TV monitors throughout the SFOF, as required. When a permanent copy of a display is required, six hard copy printers will be available to print a hard copy of the selected display.

This article is a summary of the requirements for such a data display system and a description of that system.

2. Requirements for a Display System

The need for a display system with capabilities of the DTV has become increasingly apparent with each new mission. Improvements in data transmission between the spacecraft and the DSIF and between the DSIF and the SFOF have increased the volume of data available during any given time in a mission. Also, the use of larger and faster computers within the SFOF has made it possible to provide larger amounts of processed data to the end user in real time. To output this data to the user requires a display system with a high data output rate and multiple output devices.

Previous displays within the SFOF consisted mainly of line printers and X-Y plotters distributed throughout the various user areas of the SFOF. The limitations with the use of these previous displays were:

- (1) Low information output rates.
- (2) Nonexistence or serious limitations of displays containing both alphanumeric and graphic information.
- (3) Inflexibility of display once printed (a new display must be written to show changes in data).

- (4) Limited distribution of displays because of the bulk and expense of the individual display devices.
- (5) Considerable maintenance time involved in keeping electromechanical display devices operating.
- (6) Operational requirements to keep devices supplied with paper and toner (ink).
- (7) Noticeable delay in outputting a complete display once that outputting has begun.

3. Design Approach

In order to overcome previous limitations, the design of a new display system was approached with the following basic requirements:

- (1) Real-time data display.
- (2) Multiple data displays.
- (3) Wide distribution of the displays.
- (4) Simultaneous display of alphanumeric and graphic data.
- (5) Use of volatile displays to allow easy updating without complete display regeneration.
- (6) Access to nonvolatile prints of displays when needed.

The method determined to meet these requirements included the following:

- (1) Accepting data input from the SFOF data processing computers.

- (2) Converting digital inputs from the data processing computers into an output suitable for driving television displays.
- (3) Providing real-time displays on television monitors.
- (4) Providing a multiple channel system with the ability to store and regenerate video (television) information for each channel.
- (5) Writing over the video (television) data stored in the system with new information from the data processing computers.
- (6) Providing wide distribution of the displays by use of the GCF television assembly (TVA) distribution system within the SFOF.
- (7) Using an alphanumeric and graphic data generator to combine data on the video storage memory.
- (8) Providing adequate resolution for graphic data.
- (9) Providing a hard copy printing system that can convert the video storage signal of any display channel into a permanent copy when requested.

4. DTV Description

The DTV consists of a computer subassembly and a display subassembly as shown in Fig. 1. The computer subassembly interfaces with two IBM 360/75 computers in the SFOF central processing system and accepts digital messages intended for output to the display subassembly. It also controls the hard copy request and print sequences. The computer subassembly acts to buffer display messages and distribute them to the correct locations in the display subassembly in the most efficient manner possible.

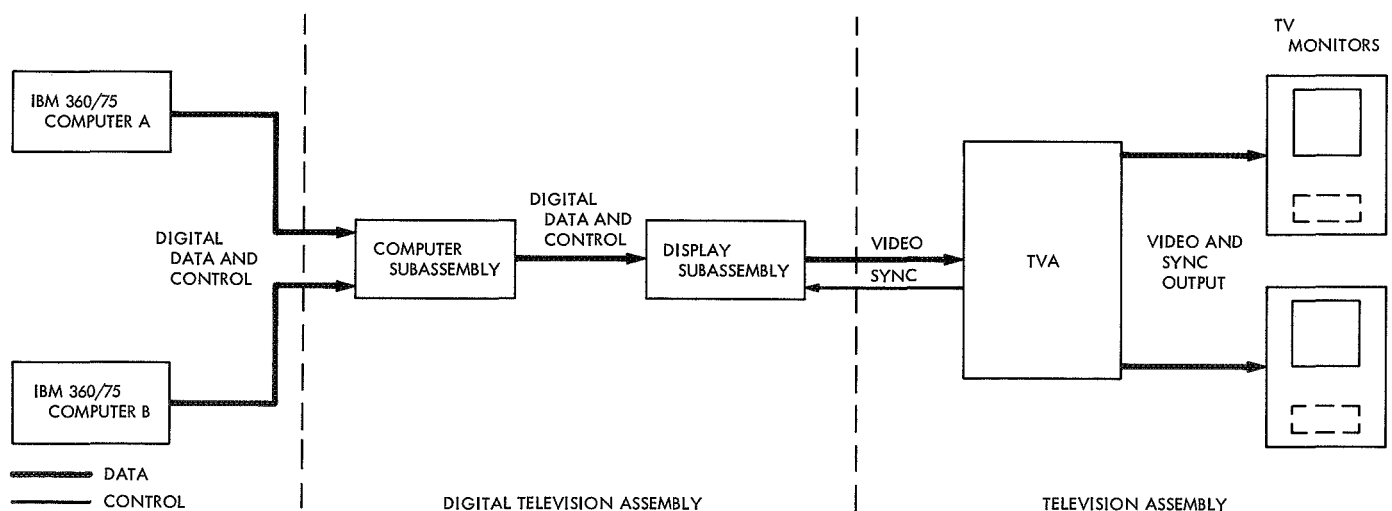


Fig. 1. DTV block diagram

The display subassembly contains the electronics necessary for the conversion of digital messages into video signals (display generation) and also for storage and regeneration of a complete video display pattern for each DTV channel. The video signals are outputted to the TVA for distribution throughout the SFOF on TV monitors.

Also, contained in the display subassembly is the equipment necessary for providing a printed hard copy of any DTV channel's display.

5. DTV Computer Subassembly

Equipment within the computer subassembly consists of two computer interface controls (CICs) and two Control Data Corporation CDC 3100 computers. Each computer includes the following peripherals: three digital

magnetic tape units, a card reader-punch, a line printer, and a shared disk memory storage device. This subassembly is shown in Fig. 2.

Each CIC provides an interface between one IBM 360/75 computer and either of the two CDC 3100 computers. Each 360/75 input can be independently switched to either CDC 3100 computer by the CIC.

Each CDC 3100 computer has a 16k-word memory, a 24-bit word size, and a cycle time of 1.75 μ s. One CDC 3100 will be used on-line to accept input data via the CIC and to control the outputting of this data to the display subassembly. Depending on mission support requirements, the second CDC 3100 will be used as a back-up computer; it will also be used as a display development computer for continuing development of the DTV.

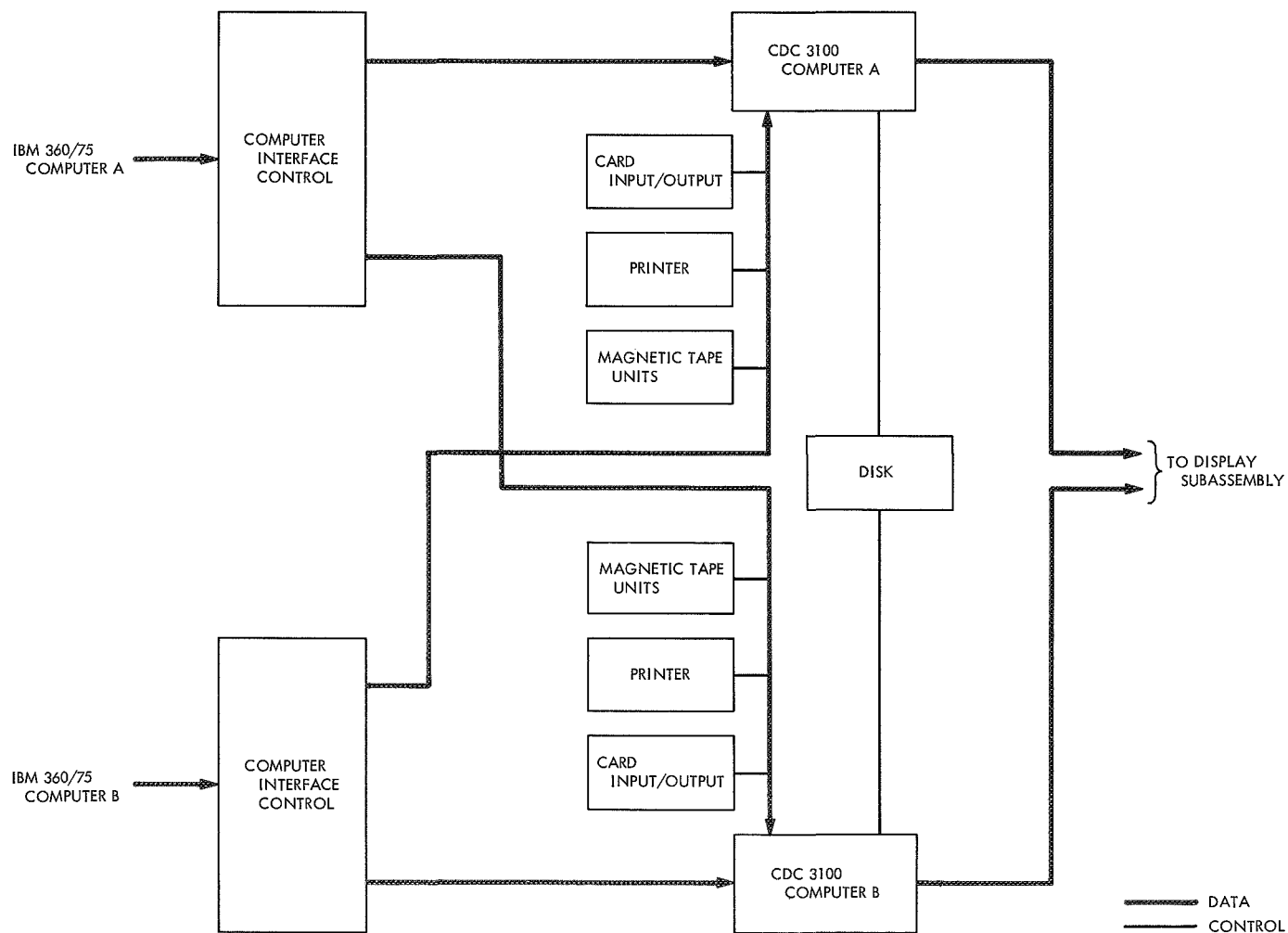


Fig. 2. DTV computer subassembly

The peripherals of each CDC 3100 are used to support operation of the computer subassembly and also assist in the further development of the DTV.

Within the computer subassembly, one CDC 3100 will normally handle all incoming DTV messages and hard copy requests. It will buffer these messages in queues slated for the display channels in the display subassembly and output them to the display channels as they are ready to accept them.

Also, requests for hard copy printouts of DTV channels are accepted by the on-line CDC 3100. A request causes the input messages to the requested DTV channel to be held in their queue until the display channel information can be transferred. The information is transferred to an alternate hard copy storage in a matter of milliseconds. Display messages are then permitted to continue to the requested display channel.

6. DTV Software

Operation of the computer subassembly will be internally controlled by the DTV operating system (DTVOS) software which is resident in the on-line CDC 3100 computer. The DTVOS will provide management of display messages, hard copy requests, and hard copy printouts.

The DTVOS will accept formatted display data generated in the IBM 360/75s and route it to the appropriate DTV channel in the display subassembly. Additionally, the DTVOS will service requests for a hard copy of data in any DTV channel by the issuance of a hard copy print instruction when a valid request is received. To insure integrity of the hard copy printout, the DTVOS will inhibit updates to the channel to be copied until printout of a valid copy is assured.

Supporting software within the DTVOS will include routines for task management, core management, and input/output handling. Other features will include a DTV diagnostic pattern generator, a basic statistics gathering routine, system initialization and operator communication with the software, as well as supervisory functions and peripheral control routines.

7. DTV Display Subassembly

This subassembly consists of the following units as shown in Fig. 3: one system control unit, three display generator units, one display image buffer, six copy request units, and six hard copy printers.

The system control unit interfaces with the computer subassembly and provides interface and control for the display generators, display image buffer, and copy request units.

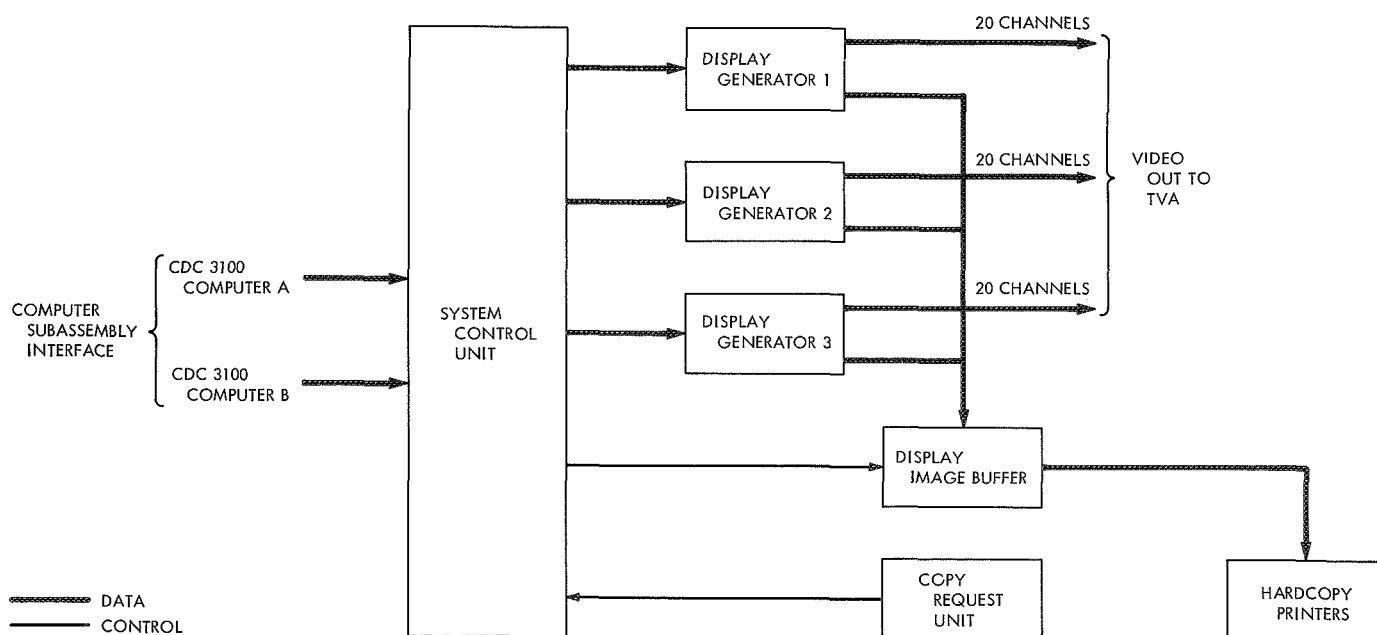


Fig. 3. DTV display subassembly

Each display generator contains a digital buffer for storing incoming digital display messages, logic for character and graphic data generation, and a disk memory for video storage with automatic signal regeneration capability for 20 channels. The incoming digital messages are converted into video information and written on the correct channel of the disk memory by the character and graphic data generation logic. These channels are synchronized to the TVA so that their outputs can be directly transferred to the TVA for distribution in the SFOF.

The display image buffer contains disk memory storage of hard copy output data and the selection and interface logic to transfer any DTV channel video signal into its disk memory storage. It has the storage capacity and output logic for driving six hard copy printers.

Each of the six copy request units contains the controls for selecting and requesting a hard copy of any DTV channel. The logic for the copy request unit is contained in the system control unit.

Each of the six hard copy printers contains the logic and mechanics to convert the output from the display image buffer into a 6- × 8-in. image of the requested DTV display channel and print it out in about 11 sec.

Both the copy request units and the hard copy printers will be located in the various user areas of the SFOF. Hard copy requests will be initiated by the user at his copy request unit and the requested display will be outputted to the printer associated with that copy request unit.

When a copy request is made, it is routed to the computer subassembly by the system control unit where it activates the hard copy request sequence. The computer subassembly issues a DTV channel transfer and print command to the display image buffer (via the system control unit). The display image buffer then causes the video signal of the requested DTV channel to be transferred from the display generator into its video storage memory. This signal is then output in a format compatible to the hard copy printer.

8. Synchronization and Distribution of DTV Output

One video output signal from each DTV channel will be transmitted to the GCF TVA. The TVA, which is a part of the GCF wideband system, will supply the switching circuitry and amplifiers needed to distribute the DTV video signals to the TV monitors in the mission support areas.

In order for the DTV video signal to be correctly transmitted to the TVA, it must be synchronized with the TVA. Correct transmission will be accomplished by synchronizing the disk memory of each display generator to the TVA by means of a servo control system. The servo derives its timing control from the TVA synchronizing signals.

9. Capabilities of the DTV

The DTV will contain 60 channels of display, controllable from the IBM 360/75 computers. Each display will have an element resolution of 640 elements (horizontal) by 480 elements (vertical) and simultaneous graphic and alphanumeric display capability. The DTV will have a repertoire of 96 standard ASCII characters that it can generate and display in four sizes.

The alphanumeric content of any display can consist of either 40 or 80 characters per row and either 20 or 40 rows, depending on the character size used.

The DTV will have six hard copy printers, each with an associated copy request unit. The printout from these printers will cover a 6- by 8-in. area; the requested display will be produced element for element in 11 sec from start of printing. The print will be made on an 11-in.-wide roll of paper and the paper advance is designed to provide an 8½- × 11-in. sheet of paper with each printout.

Table 1. Capabilities of the DTV

Characteristic	Capability	Remarks
Display channels	60	Expandable to 120
Graphics generation	Yes	
Display resolution	640 × 480 elements	
Alphanumeric generation	Yes	
Character repertoire	96 ASCII characters	
Character sizes	4	
Characters per row	40 or 80	Dependent on character size
Character rows per display	20 or 40	Dependent on character size
TVA compatible	Yes	
Input source	Two IBM 360/75 computers	
Hard copy printers	6	Expandable to 19
Printed image size	6 × 8 in.	
Hard copy resolution	640 × 480 elements	
Hard copy print time	11 sec	
Number of copy request units	6	Expandable to 31

Because the DTV outputs into the television assembly, the DTV displays are capable of wide distribution throughout the SFOF on either 9- or 14-in. TV monitors. Furthermore, because every DTV display will be under the control of the IBM 360/75 computers, each will be fully capable of being updated in real time or of being completely replaced with a new display format.

The DTV has been designed for expansion capability to 120 display channels, 19 hard copy printers, and 31

copy request units. The capabilities of the DTV are shown in Table 1.

10. Conclusion

The DTV assembly is currently being implemented. The computer subassembly is an existing display computer system that is being modified to this requirement. The display subassembly is being manufactured by Data Disc, Inc., and is slated for delivery in September 1970.

B. Contrast Ratio Determination for the SFOF Video Image Display, J. J. Volkoff

1. Introduction

The SFOF Mark III central processing system will include a video processing facility that has the capability to display and print tonal images through video processing of digital image data. This display and print processing shall be performed within the video image display subsystem (VIDS) of the SFOF. The images will be displayed on high-resolution monitors that have the capability to display a large number of discernible grayshades requiring a minimum ratio for a given monitor configuration and ambient light condition.

This study is concerned with the effect of ambient light upon the contrast ratio, and upon the output light of the display. These results shall be used to establish a monitor configuration and ambient light condition to achieve a desired photometric quality and a discernibility requirement.

2. Definition

The contrast ratio of a cathode ray tube (CRT) display is defined as the quotient of the maximum luminance divided by the minimum luminance. Reduction of contrast ratio results from the scattering and the reflection of light. Light can be dispersed by reflections from the tube walls, scattering from CRT geometry, and scattered electrons. These dispersions can be significantly reduced through filtering, tube geometrical configuration, and tube design. Even though these dispersions reduce contrast ratio, their effect upon contrast ratio is small compared with the effect of the reflections from ambient light incident upon the faceplate of the CRT. Reflections from

ambient light, however, can be reduced through the use of filter devices.

Consider the CRT configuration as shown in Fig. 1. An electron beam imparts energy to the phosphor screen producing light which is transmitted through the glass faceplate and filter screen of the CRT system. Ambient light passing through the filter screen is reflected from the glass faceplate and the phosphor screen. Combining the transmitted light generated by the electron beam with the reflected ambient light results in the total light emanating from the faceplate of the CRT.

The amount of light contributed by the total reflections of ambient light and emanating from the CRT system is

$$L_a(1 - f)^2 [t^2 r_s(1 - r_g) + r_g]$$

where L_a is the total illumination of the ambient light incident upon the CRT system, t is the light transmission factor of the glass faceplate, r_s is the phosphor screen reflection coefficient, r_g is the glass faceplate reflection

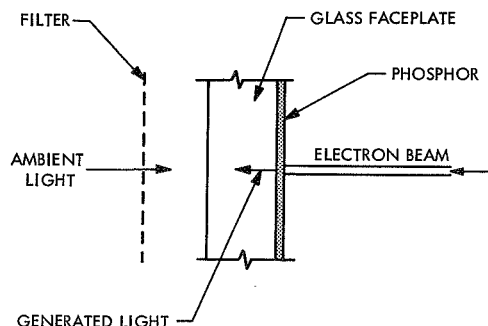


Fig. 1. Cathode ray tube configuration

coefficient, and f is the filtering factor of the filter screen. It is assumed that the reflection coefficient of the filter screen is negligibly low.

For a given luminance L_s generated at the phosphor screen by the electron beam, $(1 - f)tL_s$ represents the amount of light transmitted from the CRT system. The total luminance L_t emanating from the CRT system, including the effects of ambient light, is then

$$L_t = (1 - f) \{ tL_s + L_a(1 - f) [t^2 r_s (1 - r_g) + r_g] \} \quad (1)$$

The highest contrast ratio which can be displayed by the CRT may be considered to be the luminance gain G . Gain is expressed as white-level luminance $L_{s(\max)}$ (maximum level), divided by the black-level luminance $L_{s(\min)}$ (minimum level), each produced at the phosphor screen such that $L_{s(\max)} = G L_{s(\min)}$. Using Eq. (1), the contrast ratio C_r of the displayed image, including ambient light incident upon the CRT system, can be expressed as

$$C_r = \frac{L_{t(\max)}}{L_{t(\min)}} = \frac{L_{s(\max)} + (1 - f)kL_a}{L_{s(\max)}G^{-1} + (1 - f)kL_a} \quad (2)$$

where

$$k = \frac{t^2 r_s (1 - r_g) + r_g}{t}$$

3. Contrast Ratio Evaluation

For the evaluation of the contrast ratio of the VIDS high-resolution monitors as a function of ambient light, the following set of CRT configurations are established:

- (1) The phosphor screen is comprised of Willemite (P4). The reflectivity coefficient r_s for a representative P4 screen was measured under actual florescent lighting in the SFOF and found to be 0.76.
- (2) The faceplate consists of tinted glass that has an average light transmittance t of 0.63 integrated over the spectrum of light (Ref. 1). Reflectivity coefficient r_g was taken to be 0.04 (Ref. 2).
- (3) The CRT gain G may be varied from a minimum value of 33 to a maximum value of 100.¹

Using these values for the parameters in Eq. (1), total luminance L_t at white level as a function of ambient light

for various neutral-density filter screens is shown in Fig. 2. This figure is based on a nominal output luminance of 50 ft-L emanating from the CRT at zero ambient light condition. By Eq. (2), contrast ratio also as a function of ambient light for various neutral-density filter screens and for a CRT gain of 33.0 is shown in Fig. 3.

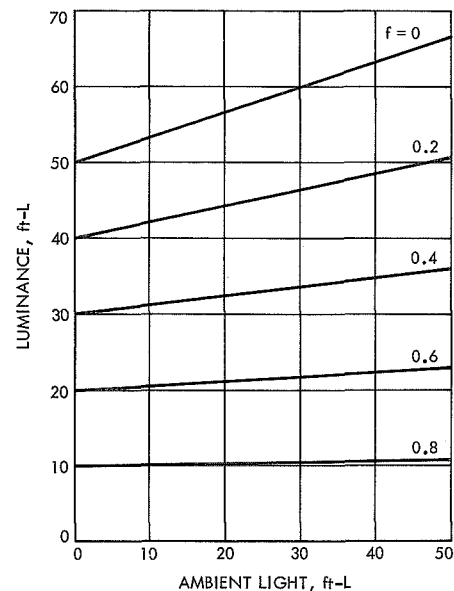


Fig. 2. White-level luminance from CRT system vs ambient light for various filtering coefficients f

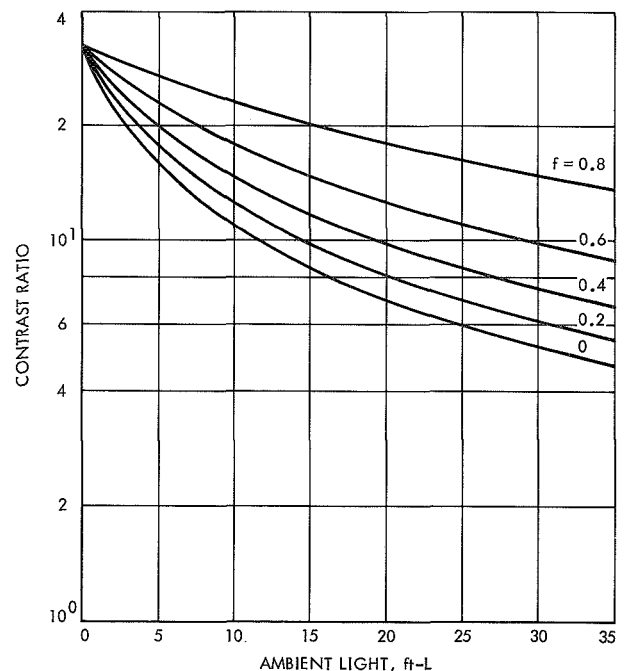


Fig. 3. Contrast ratio vs ambient light for various filtering coefficients f and a CRT gain of 33.0

¹Diem, W., *Video Image Display Subsystem, Space Flight Operations Facility, Design Requirements for*, May 25, 1970 (JPL internal document).

4. The Effect of Gain

The effect of gain upon displayed contrast ratio of a monitor system, possessing a dc restorer which maintains the back porch despite changes in signal amplitude can be expressed by a factor ρ defined by

$$\rho = \frac{C_r(G)}{C_r(G_0)} \quad (3)$$

where $C_r(G_0)$ is the contrast ratio at a reference gain factor G_0 and $C_r(G)$ is the contrast ratio at some given factor G . From Eq. (2), ρ may be expressed as

$$\rho = \frac{L_{s(\max)} G_0^{-1} + (1-f) k L_a}{L_{s(\max)} G^{-1} + (1-f) k L_a} \quad (4)$$

Factor ρ as a function of ambient light for different filter factors is shown in Fig. 4, where G_0 is referenced as the minimum gain of the VIDS monitors. It can be seen from Fig. 4 that the effect of CRT gain to enhance the displayed contrast ratio grossly decreases with ambient light. However, CRT gain can be used to increase the degree of discernibility of the displayed image since contrast ratio increases with CRT gain. The maximum contrast ratio which can be developed by the VIDS monitor at a given ambient light and filter screen configuration can be found by combining the values from Figs. 3 and 4 into Eq. (3).

5. Circular Polarizer

A neutral-color circular polarizer screen filter can be used to enhance the contrast ratio of an image displayed on a CRT viewed under extreme ambient light condi-

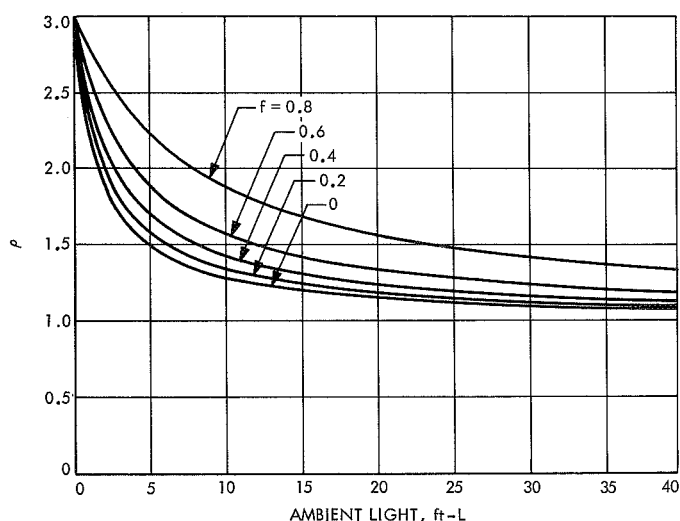


Fig. 4. Factor ρ vs ambient light for various filtering coefficients f

tions. A circular polarizer screen consists of a lamination of a linear polarizer layer and a retardation (quarter-wave) layer. The purpose of circular polarization is to attenuate the reflections of ambient light to negligible levels. This is evident from the typical transmission curves of a circular polarizer described in Fig. 5 (Ref. 3), which shows that about 35% of the light from the display may pass through a circular polarizer screen filter while attenuating the reflections of the integrated ambient light to a negligible level. An estimate of an application of circular polarization to the VIDS high-resolution monitor shows that the display should have a contrast ratio of about 31.8 under an ambient light condition of 100 ft-L. However, the maximum luminance of the display which can be observed is 17.5 ft-L.

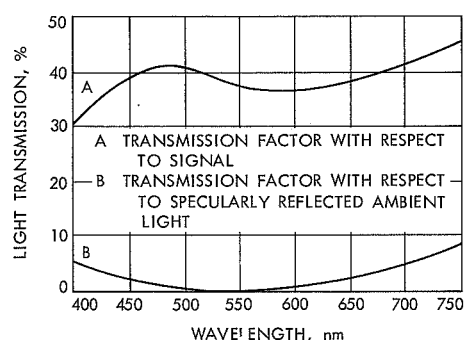


Fig. 5. Light transmission factor as function of wavelength for typical neutral-color circular polarizer screen filter

6. Conclusion

By knowing what contrast ratio is required to discern a desired number of grayshades displayed on the CRT as a function of white-level brightness, the maximum ambient light as a function of filter coefficient factor may be obtained from Fig. 3. Figure 3 represents a minimum gain condition for the VIDS monitor system. Also, the maximum total illuminance emanating from the monitor can be found from Fig. 2. From these evaluations, a trade-off can be made between monitor configuration, maximum ambient light, and the desired photometry of the displayed image.

References

1. *Optical Faceplates*, Ferranti-Microspot Cathode Ray Tubes Catalog, Vol. 1. Ferranti Electric, Inc., New York, Oct. 1967.
2. Born, M., and Wolf, E., *Principles of Optics*. Pergamon Press, London, England, 1959.
3. *Polarized Light*, FT 3374-A. Polaroid Corp., Cambridge, Mass., Feb. 1967.

C. DSN Mark IIIA Simulation Center Development, R. G. Polansky

1. Introduction

The purpose of this article is to describe the current development activity that is taking place in the DSN Simulation Center (Simcen) in preparation for *Mariner* Mars 1971 and *Pioneer F* support.

2. Background

The current, or Mark II, configuration of the Simcen does not contain sufficient hardware to handle the requirements that have been levied upon it by the DSN and the *Mariner* Mars 1971 Project. Major hardware expansion is being carried out at this time to provide the necessary capabilities for support during the *Mariner* Mars 1971 era. The Simcen configuration being implemented now has

been designated the Mark IIIA Simcen. Table 1 shows the characteristics of both the Mark II and Mark IIIA Simcens.

3. Hardware Description

Block diagrams for the Mark II and the Mark IIIA Simcens are shown in Figs. 1 and 2. A close look at these figures reveals that the following changes have been or are in the process of being made:

- (1) The EMR 6050 input/output (I/O) computer's core memory has been expanded from 16k to 32k words.

Table 1. DSN Simcen subsystem characteristics

Subsystem	Mark II	Mark IIIA
Telemetry	Fixed pattern	Same as Mark II + dynamic/ on-line responsive math models
	Controllable pattern	
	Locally controlled math model	
Command	Long loop: 1 spacecraft to 2 DSSs simultaneously	Long loop: 2 spacecraft to 3 DSSs simultaneously
	Short loop: simultaneous 2-DSS outputs, 1 spacecraft, to SFOF	Short loop: simultaneous 3-DSS outputs, each of 2 spacecraft, to SFOF
	Operator entry to change telemetry	Same as Mark II + on-line inputs to telemetry model; simulation of DSS replies to SFOF commands
Tracking	Long loop: 1-DSS read-write-verify support	Long loop: processes command replies from 3 DSSs
	Short loop: 2-DSS read-write-verify support	Short loop: 3-DSS command system simulation
	Off-line generation of punched paper tape	On-line generation of tracking data to SFOF from Simcen
Monitor	8-tape playback, manual selection	Real-time selection of DSSs/formats; concurrent with telemetry simulation
	Fixed-pattern data blocks to SFOF	Dynamic/responsive DSS model to SFOF; simulates 3 DSSs simultaneously; on-line inputs to telemetry and tracking models
	Operations control	Same as Mark II
Operations control	SFOF clocks setable to simulated GMT	Same as Mark II
	Voice communication to DSN controllers simulating DSS operation	Same as Mark II

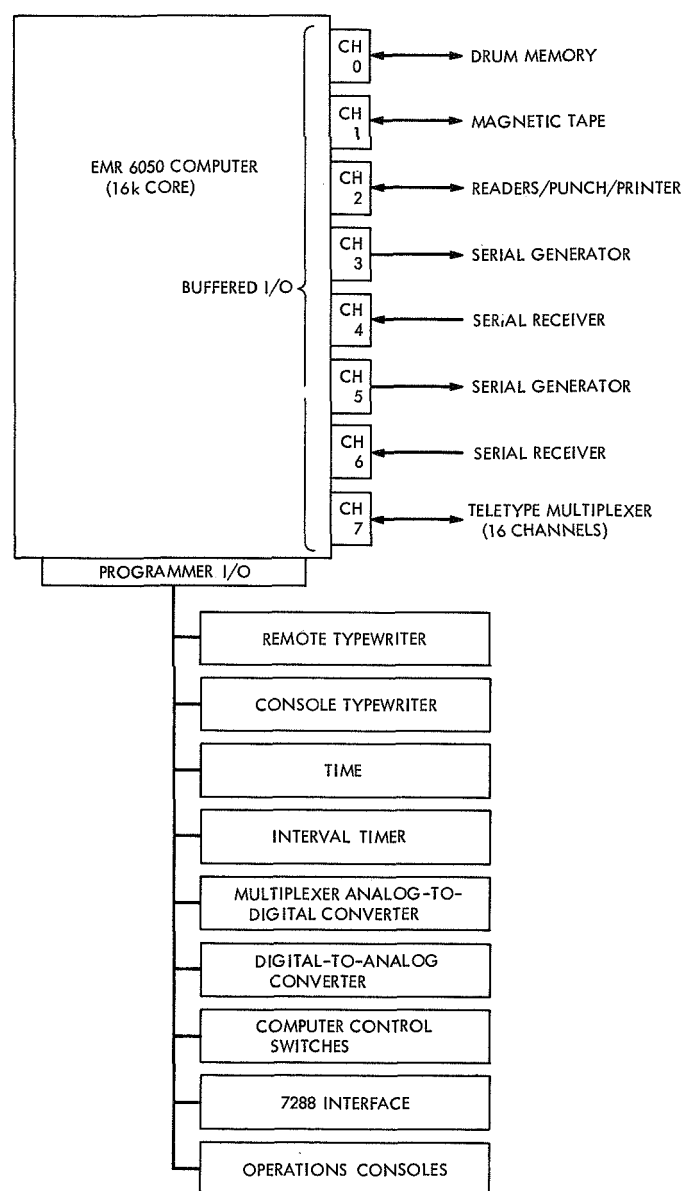


Fig. 1. Mark II DSN Simcen subsystem

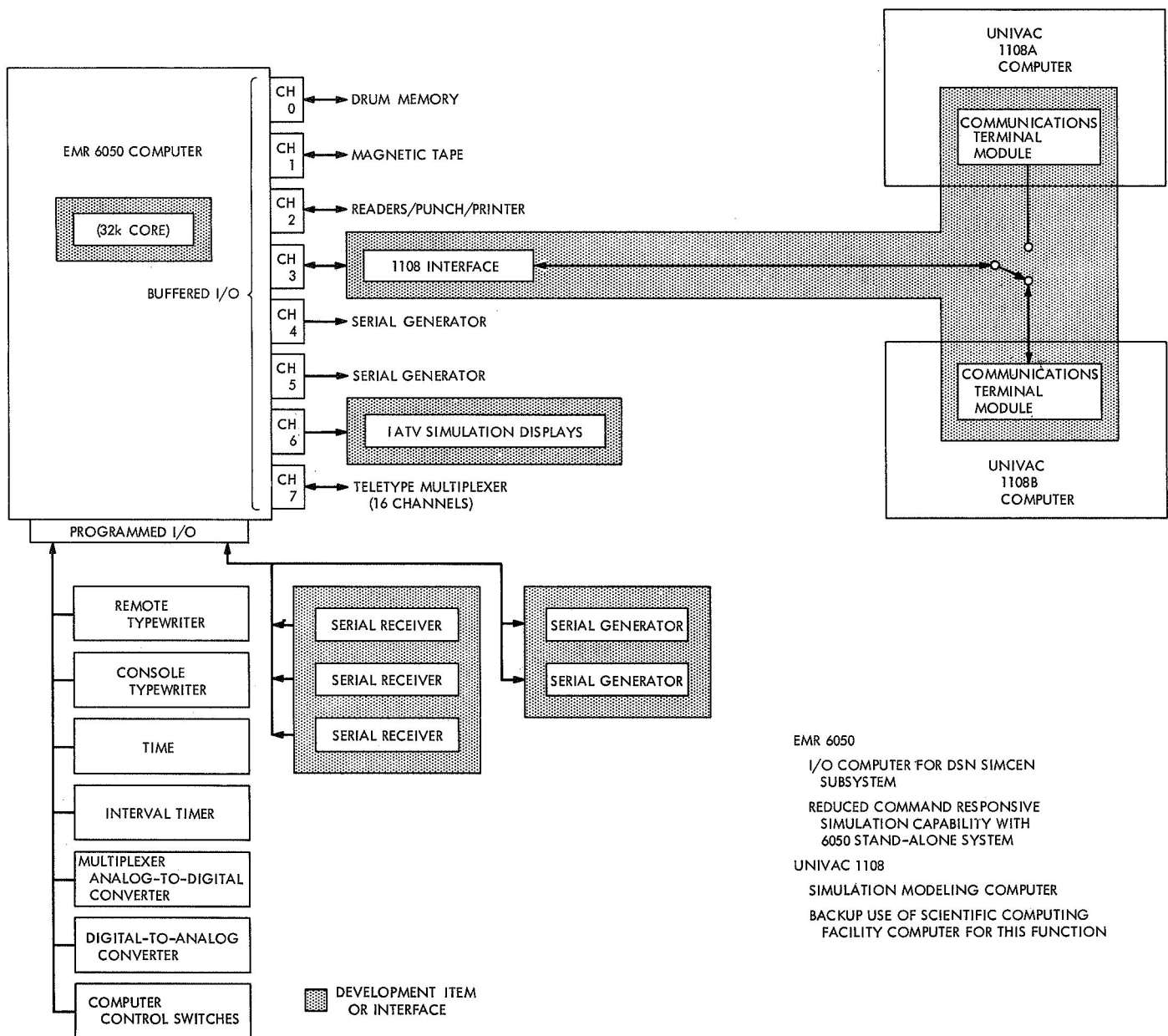


Fig. 2. Mark IIIA DSN Simcen subsystem

- (2) The serial receivers which were interfaced with buffered I/O channels 4 and 6 of the EMR 6050 have been removed from the system.
- (3) The serial generator that was interfaced with buffered I/O channel 3 of the EMR 6050 has been moved to channel 4.
- (4) An EMR 6050/Univac 1108 interface device has been designed and will shortly be installed between buffered I/O channel 3 and the 1108 computer. (The 1108 will be used as the modeling computer for the Mark IIIA Simcen.)
- (5) An interactive alphanumeric television (IATV) system will be interfaced with buffered I/O channel 6 of the EMR 6050.
- (6) The 7288 interface and the operations consoles on the programmed I/O of the EMR 6050 are being removed.
- (7) Three serial receivers and two serial generators were designed and built, and will shortly be interfaced with the programmed I/O channel of the EMR 6050.

A brief description of each of the new capabilities is presented next.

a. Core memory expansion. This item is self-explanatory. Two additional 8k-word memory modules were added to the 16k words of memory already in the machine. All supporting circuitry already existed in the computer.

b. 6050/1108 interface. This is a device that operates in a half duplex mode. In the 6050 to 1108 direction, it accepts parallel data words from buffered I/O channel 3, adds control and parity bits to each character, and transmits the data to the 1108 via a 50-kbits/s modem system.

Provisions are made so that the modem can be patched to either 1108A or B.

In the 1108 to 6050 direction, sync, parity and end-of-text characters are stripped from the output of the 50-kbits/s modem system. The data itself is blocked into 24-bit words which are input in parallel form to buffered I/O channel 3.

c. Buffered I/O serial generators. The serial generators on buffered I/O channels 4 and 5 are each already capable of operating at whatever rate, 50-kbits/s or less, the external clock provides. In normal operation, one of the generators (either one) will be operated at the 50-kbits/s rate while the other will be operated at the 4.8-kbits/s rate. The data output from these serial generators will be routed via the GCF to either the SFOF or the DSSs.

d. IATV system. This hardware is to be used as the control and display portion of the Mark IIIA Simcen. Physically, it consists of eight interactive keyboard/cathode ray tube terminals, and two high-speed printers, each interfaced through a multiplexer to buffered I/O channel 6 of the EMR 6050 computer. Each keyboard is capable of entering requests into the computer and each cathode ray tube and printer is capable of displaying whatever data was requested by its associated keyboard, through the buffered I/O channel.

e. Programmed I/O serial receivers and generators. These generators and receivers are designed to operate at a variety of data rates, selectable by the resident program or manually by each device. The intent is that they will be used to interface with the 4.8-kbits/s GCF modems during the *Mariner* Mars 1971 era. The receivers will be used to "look at" command data going to the DSSs and at monitor data being received from the DSS. The generators will, as described previously, output data via GCF hardware to either the SFOF or the DSSs.

D. Diagnostics for the SFOF Mark IIIA Central Processing System: Standalone Acceptance and Maintenance Routines, R. A. Wells

1. Philosophy

To verify proper performance of all elements in the SFOF central processing system equipment configuration and its interfaces with other facilities, it has become standard practice in previous developmental periods to produce and deliver a complete set of diagnostic software to permit the isolation and correction of hardware faults which might complicate or jeopardize the accomplishment of mission objectives. These routines are particularly essential where JPL-developed devices and linkages are involved and for which no vendor-furnished diagnostics are available. In these instances, it is required that comprehensive standalone diagnostics¹ be originated by JPL for the early stages of hardware checkout. Vendor diagnostics, often called customer engineering or CE diagnostics, are generally provided for testing of computer mainframes (arithmetic functions, memory, etc.) and on-line peripherals of their own manufacture. While these are also of a standalone nature, they are not treated herein since they are developed, maintained, and generally operated by vendor or contract maintenance personnel and are not compatible with SFOF software. Also of no concern here are wired-in equipment test features which require no special programming.

2. Objectives

In the process of equipment development, it becomes necessary to have some means to:

- (1) Exercise the equipment under development.
- (2) Act as a data generator/sensor for related equipment.
- (3) Gather performance (i.e., error) statistics.
- (4) Enable equipment acceptance and buyoff from the developer or vendor.
- (5) Demonstrate equipment capabilities to users.
- (6) Perform maintenance and exercise selected or suspected functions.
- (7) Verify proper device or channel operation.

¹Standalone diagnostics have been arbitrarily defined in the Mark III era as independently loadable routines not *primarily* under the control of the resident 360/75 diagnostic monitor.

Since it is usually impractical or uneconomic to tie up major portions of the facility for these purposes, independent standalones are the most suitable solution.

3. Background

In the Mark II era (7044/7094 computer strings), two families of diagnostics were produced:

- (1) SYSCKO-INERT,² which required total dedication of the 7044 (and sometimes the 7094) for operation of its dependent routines.
- (2) SYSCKO-LIVE,² which resided and executed compatibly with other jobs (such as mission data processing) under the 7044 redesign operating system, and required dedication of only those system elements under test.

In addition, many independent standalones were produced for equipment acceptance and other specialized purposes.

4. Mark IIIA Evolution

In the Mark IIIA environment, major emphasis has been placed on live diagnostics, the inert monitor concept has been superseded, and standalones have been confined to the following major areas:

- (1) Mission display board (MDB).
- (2) Digital TV (DTV).
- (3) Simulation center (Simcen).
- (4) High-speed data (HSD).
- (5) Wideband data (WBD).

Figure 1 shows the equipment which can be tested, along with the hierarchal relationships of each standalone diagnostic. Table 1 gives the definitions of nomenclature used in Fig. 1.

5. Mission Display Board

Because of the limited memory of the MDB processor, its standalone diagnostics must be loaded for each occasion and displace the live operational software. Electro-mechanical responses of the VIGICON scribing projectors can be checked or, as a separate test, the integrity of the 50-kbits/s half-duplex ASCII serial channels to the 360/75s. (CE diagnostics test all standard DDP 416 devices and computer functions.)

²SYSCKO = system checkout.

Table 1. Nomenclature

BMXR	block multiplexer
CCTV	closed-circuit television
CHAN	channel
DIAG	diagnostic
DIS	data instrumentation subsystem
I/O	input/output
LDA	line driving amplifier
MUX	multiplexer
MX	multiplex
PCM	pulse-code modulated
PROJ	projector
RCVR	receiver
RT	real time
SCF	Scientific Computing Facility
TCP	telemetry and command processor
TTY	teletype
TVA	TV assembly
TWR	typewriter

6. Digital TV

These diagnostics are loaded into either CDC 3100 computer and exercise the DTV display generators, the display buffers for hard copy output, and the ability of the DTV copy request panels to select the desired output. If the 360-to-3100 data channel is to be tested, the 360 will be required to pass known data patterns across this one-way link in 8-bit parallel bytes. (CE diagnostics test all CDC 3100 functions and on-line CDC peripherals.)

7. Simulation Center

This family of diagnostics checks all JPL-unique attachments to the EMR 6050 (Fig. 1). The 50-kbits/s half-duplex serial channel from the EMR 6050 computer is tested by transmitting known data blocks to the Univac 1108 computer, which returns them unaltered to the Simcen for checking. Pulse-code-modulated serial generators and receivers can be tested within the Simcen by

loop patching. The GCF diagnostic utilizes the support of a comparable 360 program to verify proper functioning of the HSD input and output equipment and lines.

8. High-Speed Data

This standalone, while requiring some services of the live 360/75 diagnostic monitor, provides more extensive capabilities than are to be found in the on-line HSD diagnostics. Specifically, in addition to passing 1200-bit data blocks at 4800 bits/s across the various HSD links, it can also gather error statistics for long-range analytical studies. It also acts as the generator/sensor element to support testing of individual GCF components and lines.

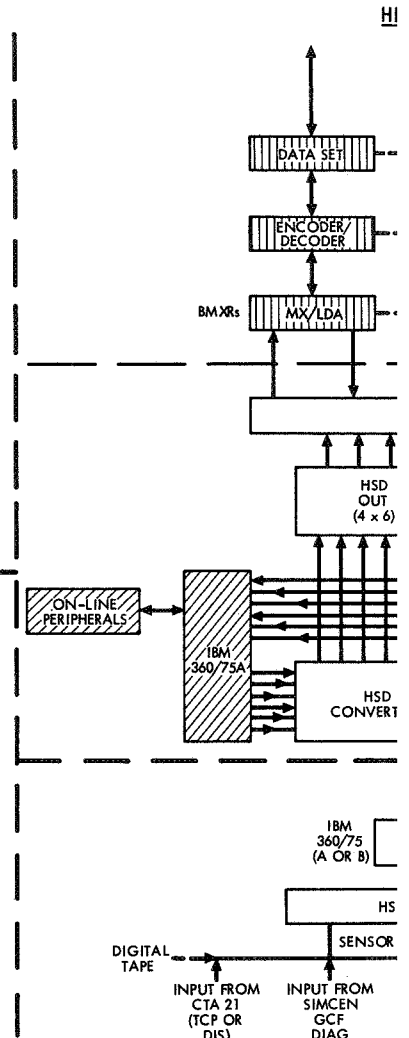
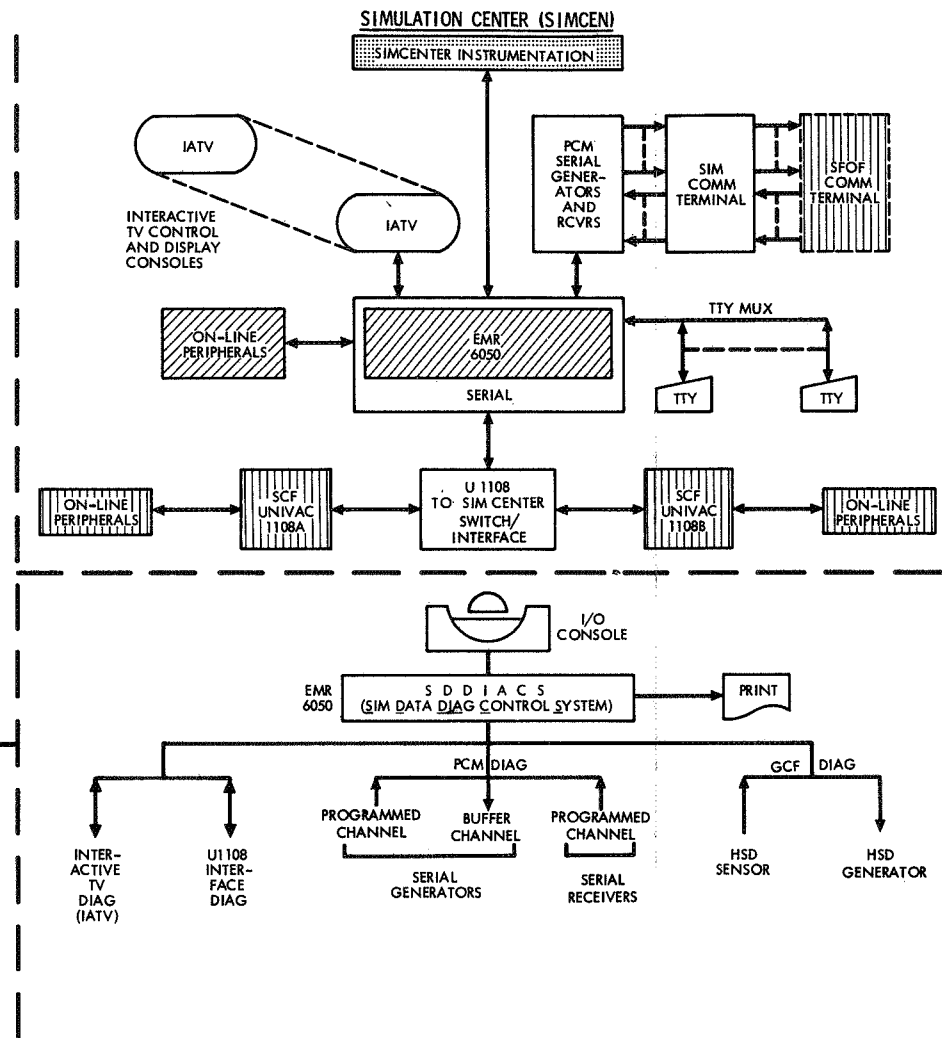
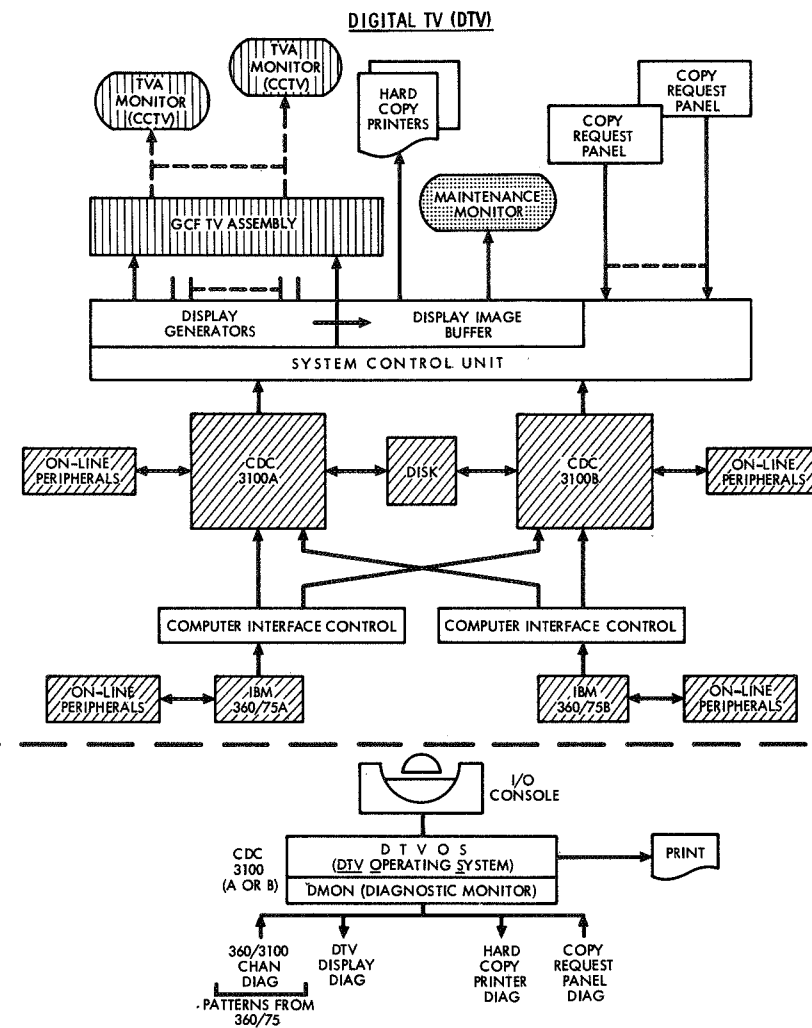
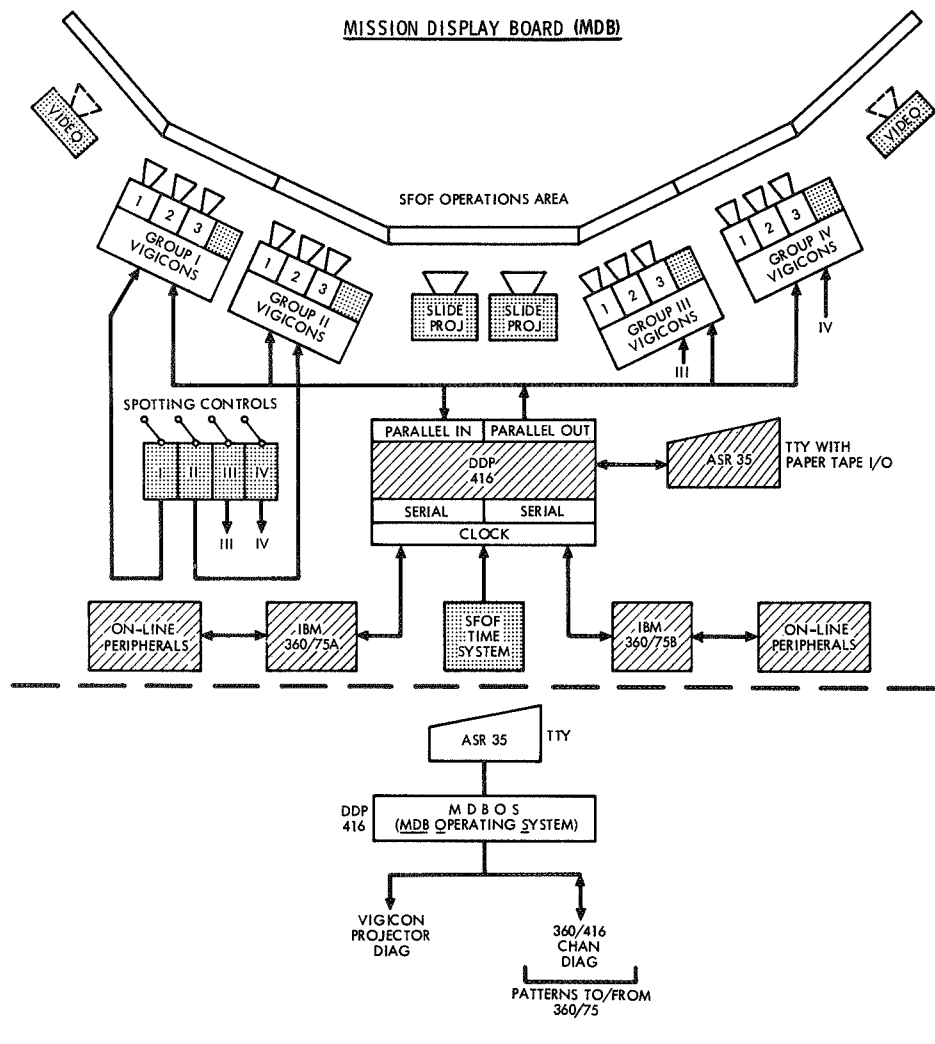
9. Wideband Data

This test routine is essentially a 50-kbits/s version of the HSD standalone routine. Because of hardware limitations, only the WBD sensor program is employed to check incoming wideband data from the DSS 14 or CTA 21 telemetry and command processors. As with the HSD sensor diagnostic, error statistics may be obtained with the aid of this program.

Since it is the intent to keep these standalone diagnostics as useful and comprehensive as possible, the cognizant hardware subsystem engineers seek to improve the programs as seems advantageous. For example, as performance idiosyncrasies of particular devices or channels are uncovered, the appropriate diagnostic is upgraded to exercise these potentially troublesome functions.

10. Conclusion

All of the standalone routines described are in use for SFOF subsystem and assembly checkout, except for the MDB diagnostics which remain to be completed. Utilization of these methods has enabled installation and acceptance to proceed with a minimum of competition for SFOF resources.



TESTED WITH VENDOR-FURNISHED DIAGNOSTICS (diagonal lines)

NOT TESTED WITH STAND ALONE DIAGNOSTICS (dots)

NOT A PART OF SFOF (vertical lines)

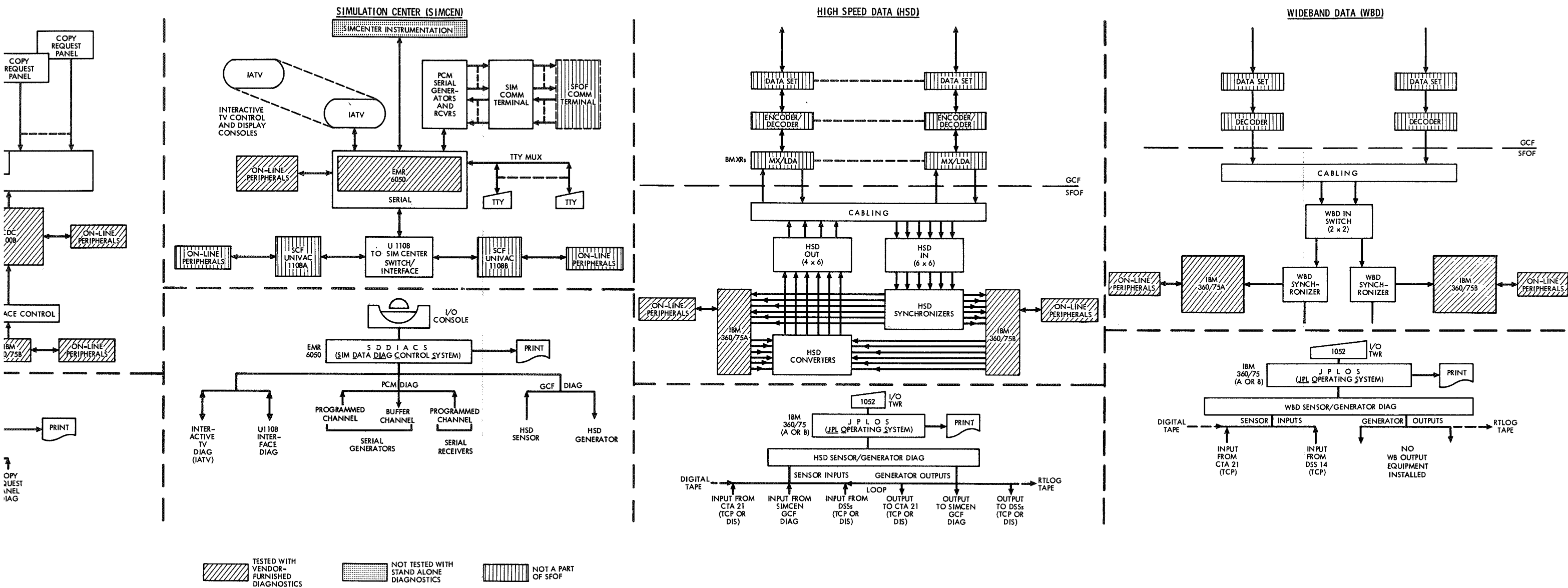


Fig. 1. SFOF and Simcen standalone diagnostic configurations

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E. High-Speed Data, SFOF Outbound Communication, P. G. Mullen

As part of the SFOF Mark III configuration to support *Mariner* Mars 1971 and *Pioneer* missions, there will be high-speed data (HSD) transmission capability for both inbound and outbound communication. The outbound HSD data communication will be used to transmit command blocks, predicts, standards and limits, sequence of events data, and scheduling information. The HSD line rate is 4800 bits/s with data transfers, using the standard DSN 1200-bit blocks. The SFOF HSD block format consists of a header, the data body, and error detection sections.

The outbound data flow in the SFOF is from the central processing unit (CPU) to an IBM 2909 input/output channel to the HSD converters through a switcher to the GCF. In the GCF, the data blocks enter the block multiplexer, are sent to an encoder and then to the data set for transmission on the HSD lines. The CPU consists of two IBM 360/75 computers designated 75A and 75B, one acting as the primary computer and the other as an alternate or back-up computer. The data block header and data body will be originated here and transferred out of the computer through an IBM 2909 asynchronous data channel, general-purpose output (GPO) subchannel. The HSD converter accepts the 2909 GPO subchannel 32-bit parallel word and converts it to the serial format for transmission. The HSD converter must communicate and coordinate with both the 2909 and the block multiplexer to perform this task. The HSD outbound data switcher allows any one of the converters to interface with any one of the HSD lines. Thus, any 2909 GPO subchannel can output to any data line. The data block is then sent to the block multiplexer (BMXR) in the GCF. The BMXR interleaves the data blocks with filler blocks and thus provides a continuous outbound data stream. The encoder accepts the first 1164 bits of each block from the BMXR, either data or filler blocks, and adds the remaining data to complete the 1200-bit block. The complete data and filler blocks are then sent to the data set for transmission to the desired

location. Among the stations that will receive outbound data are the DSIF stations, Boulder, Colorado, Ames Research Center, and CTA-21.

Present plans call for six HSD lines used for both inbound and outbound communication. Because the data sets used do not allow for splitting of the transmit and receive data lines, the six lines will provide a capability of six total simultaneous transmissions. The 2909 asynchronous data channels for 75A and 75B have a present capability of four HSD output subchannels each. The HSD converters will be designed to interface with either 2909 GPO subchannel and through the switcher can communicate with each of the HSD lines. Thus, six of these units will be built to handle the present requirements. The converters will be allocated as follows:

Converter	IBM 2909 GPO subchannel	IBM 360/75 computer
1	300	75A
	300	75B
2	310	75A
	310	75B
3	320	75A
4	330	75A
5	320	75B
6	330	75B

Either computer can transmit from four subchannels with the alternate computer, using the remaining two HSD lines if needed.

All units in the SFOF outbound communication link are commercially available items except the HSD output switcher and the HSD converters, which will be developed by JPL. The switcher will be a single unit capable of handling eight converter inputs and sending to eight HSD lines. A modular concept will be used in construction of the converters to allow for future expansion by addition of new units.